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ABSTRACT

A review of computer assisted instruction research and recent meta-analytical reports suggests that all research on the learning benefits of the instructional uses of computers should be halted until there is a plausible reason to expect that computers are instrumental in learning, since all existing evidence indicates that computers do not yield learning benefits. Evidence to the contrary is subject to compelling rival hypotheses concerning novelty effects and instructional method/content effects on learning. A review of recent symbol system theories and existing evidence suggests that, while cognitive skills can be cultivated with computer-related symbol systems, the effects are already available from other mediums. Computers are useful in delivering instruction and may influence instructional cost or distribution equity, but they should not be expected to contribute any unique effects to learning. Research that compares computers with other instructional media should be deemphasized, and caution should be exercised with media attribute research, as it does not translate to prescriptive theories. Instead, focus should be on research that could contribute to both descriptive and prescriptive instructional theory. Ten references are listed. (Author/LMM)

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Learning from Computers: Theoretical Problems

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Research on the educational benefits of computers has been steadily increasing. About eight percent of this year's AERA program is devoted to papers on computer use in education (i.e. 155 papers in 42 sessions out of approximately 2,000 papers). While many of these papers are conceptual rather than experimental, it seems that we have devoted considerable resources to research on this new technology. Yet, the dominance of computer concerns in this program is a reflection of it's place in the educational research literature. About five years ago, Kulik, Kulik & Cohen (1980) found more than 500 studies that compared conventional teaching media with computer based instruction (CBI). One suspects that the sum would be considerably higher if a comparable survey was conducted now.

The goal of this presentation is to; 1) critically examine computer research questions in light of the history of media research; 2) to describe familiar findings that result from reoccuring questions; and 3) suggest a redirection of focus to more theory oriented studies. The major thrust of the argument to be presented will caution against the current trend. It will be suggested that we stop all research on the learning benefits of computers or computer programming until there is a plausable reason to expect that computers are instrumental in learning. More theory-focused research on computer "attributes" will be described but it will be suggested that these studies actually belong to the larger area of instructional methods research. As such, they also contribute to instructional theory. The role of computer research in two different types of instructional theory will be described.

Repeating Historical Errors

Media enthusiasms are a reoccurring phenemenon in education (e.g. Saettler, 1964). It seems that each new technological development for storing and delivering information rekindles the hope that we will increase learning outcomes more than "older" media. This has been the case in the introduction of the illustrated textbook, photography, movies, radio and television. Where reserchers have been engaged with these enthusiasms, they have tended to ask very similar questions for each new medium. Those questions seem to reflect intuitive assumptions about the "effects" of recent media on learning and performance. They tend to be expressed in one of the following forms:

** Does the newer medium yield more learning than the "older" or more conventional medium for instruction?

** Is there an interaction between instructional medium and curriculum content (i.e. do some media teach certain content more effectively than other media?).

** Is there an interaction between instructional medium and instructional methods (i.e. do some media present certain methods better than other methods?).

** Are there specific features of newer media that have unique cognitive or behavioral effects for learners?

There are many reviews of studies that focus on questions similar to these (c.f. Clark, 1983 for a list).

If one were to express a summary of the conclusion reached by these surveys to the questions raised above in a "forced choice", one-word format--it would be a definite "no". In a recent review of general media research that included CBI, Clark concluded that "...media do not influence learning under any conditions. Even in the few cases where dramatic changes in achievement or ability have followed the introduction of a medium...it was not the medium that caused the change but rather a curriculum reform that accompanied the change." (1983, p. 445).

There are many reasons why the very large volume of past research has been unproductive but a list of the most important difficulties would include:

1. In studies of media effects, medium was confounded with instructional method and content.

2. Novelty effects are evident when longer and shorter term studies are compared.

Medium vs Method and Content. Most of the comparisons between different types of media are based on the implicit assumption that there is a uniform medium such as a "computer" which can be compared with some other uniform medium such as a "teacher". Such comparisons require that all variables other than the media that are competing be held constant. This requirement includes instructional method or strategy, curriculum content and so on. A moment of reflection will suggest that if such conditions are achieved there would be absolutely no reason to expect learning advantages for any medium over any other. This hindsight has been fortified by the meta-analysis of computer research by Kulik and his colleagues at the University of Michigan (e.g. Kulik, Kulik & Cohen, 1980). While they found that the typical computer comparison

demonstrated a .5 standard deviation advantage for computers over more conventional media on final examinations, the advantage was reduced to .13 when the same teacher developed all media presentations. Presumably, when one teacher produces all treatments the content and instructional method is more likely to be held constant and the effects of computers in the resulting achievement is negligible.

Of course the medium comparison question has its place. School officials may want to evaluate the impact of using computers for delivering instruction as a relief to teachers. When properly programmed, computers can act as efficient delivery devices for instruction, testing and school records. However, the evidence seems to be overwhelming that any information thus gained from the computer is not different in a psychological sense from the same information gained from any other medium for delivering instruction to the student. There simply are no unique contributions to learning that can be traced back to the computer.

Novelty effects. Researchers are not alone in their fascination with the computer. The second rival hypotheses offered to explain learning gains that show up in many studies attributed to computer instruction is the apparent interest shown by students in computerized lessons. In secondary school computer experiments surveyed by Kulik, Bangert & Williams, (1983) an average effect size of .32 for computer instruction was misleadingly large. In studies lasting four weeks or less computer effects were .56 standard deviations in learning scores. This reduced to .30 standard deviations in studies lasting 5 to 8 weeks and furthur reduced to .2 standard deviations after 8 weeks.

Here also there are advantages to be gained from the intrinsic interest generated by those of us interested in computers. Many school principals and teachers have found that community members are willing to be engaged in new computer programs and their positive experiences can be redirected to other areas where support is required. Similarly, formerly disaffected students might be reengaged in learning activities even briefly and find other sources of motivation when the initial excitement begins to wear thin. And yet, the researcher is cautioned to carefully consider the longer term studies of CBI as an additional compelling rival hypothesis concerning the influence of "computers" on learning.

Theory Oriented Studies of Computer Effects

More recent studies of the effects of computers on learning have avoided the comparison question in favor of a more refined approach. Here, questions have been directed to more manageable constructs. Rather than ask about the

effects of "computers" these studies investigate "media attributes" (e.g. Salomon, 1979). In this approach, the capacity of computers to, for example, depict information in both digital and analogic forms, apply complex branching rules based on student learning progress and to require logical and systematic thinking for successful programming is thought to potentially enhance cognitive skills. A number of the more promising studies in this area have been recently described by Salomon & Gardner (In press). Generally, the questions deal with the way that information is selected and transformed in the acquisition of generalizable cognitive skills resulting from exposure to computer "attributes" such as screen display or branching capabilities. However, there is evidence that the media attribute research with computers has followed the same course as its television predecessor. For example, a decade ago there were a number of interesting studies conducted by Salomon (c.f. Salomon, 1979) that examined the influence of an attribute of television on the cultivation of a cognitive skill he called "cue attending". In those studies, formerly deficient cue attenders increased their skill after the opportunity to "model" a film that "zoomed" into details of paintings. Salomon plausably concluded that a media attribute (zooming) had cultivated a cognitive skill that generalized and subsequently influenced performance on other cue attending tasks. Similar reasoning lies behind the recent discussion by Pea and Kurland (In press) on the generalizability (far transfer) of cognitive skills acquired in the process of learning certain computer programming languages.

In general, the attempt of the computer attribute researchers to provide more theory focused research is based on three assumptions: 1) that the attributes used as variables would cultivate generalizable cognitive skills when used appropriately; 2) that the identified attributes would provide unique independent variables for theories that specified causal relationships between attribute modeling by students and subsequent achievement, and 3) that the resulting theory could be considered a "media" or a "CBI" theory.

After a number of years of the attribute research it seems clear that while the first assumption is supported (attributes may cultivate cognitive skills under some conditions), the resulting skills are not the unique products of computer attributes (Clark, 1983). Also important for this discussion is the fact that attribute studies do not deal with "computers" in the way that term is commonly understood. The effects found in the computer attribute research are duplicatable with nominally different but effectively similar features more closely associated with other media (e.g. television, books, teachers).

An additional conceptual limitation with attribute research is that it contains an implicit assumption that the attribute is somehow unique to the medium being studied. The zooming treatment used by Salomon is avaialble in a number of media including television, movies, and videodisc. One might also imagine simply asking students to walk up to a painting and point to a feature, walk back and repeat the exercise until cue attending skills had been gained. In the case of computer programming and its effects on the acquisition of metacognitive or other skills one might similarily expect that a range of systematic, logical procedures and concepts would result in similar skill cultivation quite apart from a computer programming language.

Problems with Computer Attribute Theory

The primary limitation with the media attribute approach is that results are interpreted as due to the medium rather than to an instructional method that could have been delivered by a range of media. If all "attribute" variables are interchangeable with a range of methods that have little connection with computers then we are no longer dealing with a "media" or "computer" theory. While this is not necessarily a challenge to the validity of a theory, it is a potentially damaging restriction on the range of related research that will be considered when hypotheses are considered. An area that generates a fairly large literature tends to become insular. In the case of computer research the risk is great. Implicit in both the language and the assumptions underlying much of the media attribute research is that some unique features of computers will contribute to our understanding of instruction and learning. The tendency is therefore to limit research and theory in this area to treatments typically associated with a medium rather than to investigate the more generic problem. In this case the generic category for most computer attribute research is probably the study of instructional methods. The theory being implicitly examined by most instructional methods research is instructional theory (Shuell, 1980) or instructional design theory (Reigeluth, 1983). Developments in this area have been both rapid and recent.

The Place of Computers in Instructional Theory

There is increasing agreement that instructional theory should focus on three sets of variables: 1) instructional methods; 2) cognitive processes that moderate the effects of methods, given 3) different outcomes. Current research by those interested in developing a research-based technology of training (e.g. Reigeluth, 1983) identifies two levels of theory; 1) descriptive and, 2) prescriptive.

Descriptive Instructional Theory deals with interactions

between methods and cognitive processes and the resulting effect on outcome variables. In this type of theory hypotheses take the form of " If you present instructional method Xa to a learner with cognitive process Xc, it will produce a learning outcome with a value of Yd". Method Xa may be composed of a number of steps and/or criterial features Xa1.....Xa7 and cognitive process Xc may also be a summary statement about the students use of a number of different skills drawn from previous experience. Other constraints on learning from methods apart from cognitive processes can be included in descriptive instructional theory. Here outcomes are dependent measures that are influenced by the interaction between methods and constraints such as student aptitude. Instructional theory consists of a set of descriptive propositions about those instructional conditions that influence outcomes such as learning, satisfaction or cost/effectiveness. The logic of descriptive instructional theories does not differ from the logic of descriptive theories in physics, sociology or other disciplines.

Prescriptive Instructional Theories are the result of recent attempts to replace the passive form of the descriptive "If...then" proposition with more active statements of ways to achieve desired outcomes. The prescriptive proposition takes the form of "In order to achieve outcome Yd under instructional constraint Xa (e.g. specific aptitude and/or prior knowledge levels), use method Xc. For example, "In order to increase the long term retention for students whose ability to code or chunk information is limited, provide cognitive cues that associate the information to be remembered to a more familiar item that expresses a similar idea or function". Prescriptive theories are goal oriented while descriptive theories are goal-free descriptions of the conditions that influence or yield outcomes. Prescriptive theories must be based securely in descriptive theories but the mechanisms by which one translates a descriptive proposition into its prescriptive form is not well understood. Snelbecker (1983) makes the point that we cannot simply "turn around" a descriptive proposition and produce a prescriptive one. For example, we have solid descriptive evidence that if a student repeats a passage many times it is remembered better. However, we would not necessarily suggest that in order to increase a students memory for a passage the method of choice would be to encourage many repetitions.

One crucial difference is that descriptive theory propositions often contain sufficient conditions for influencing an outcome whereas the most effective prescriptive propositions require a knowledge of the necessary features of methods and aptitude. Computer instruction may (and often does) serve as the "method" employed in descriptive studies. Yet, attempts to translate

"computer" instruction into prescriptive principles simply do not pay off since the "necessary" features of computer instruction that influence learning outcomes are only correlated with computer delivery. Clark (1982) provided a number of examples of methods found to be sufficient and their necessary elements. For example, corn is a sufficient reinforcer for pigeons but it doesn't work with children. An analysis of the necessary features of reinforcement allows the prescriptive instructional theorist to manufacture an instance to serve nearly any population. If the construct "computer" or "CBI" implied the same set of instructional methods each time it was used there would be less of a translation problem when descriptive findings are used in instructional design. Methods that are represented by the generic CBI designation differ widely in their psychological impact during learning. In one study "computer" may mean a set of complex branching rules based on student responses to specific task features and in another study the computer may deliver instruction typical of workbooks.

Evidence from Earlier Studies. In the zooming studies of film and television attributes described earlier, a similar phenomenon was reported. While zooming cultivated cue attending (Salomon, 1979), a partial replication of the zooming research by Bovy (1983) found that a treatment using "irising" (i.e. gradually enclosing the cue in a circle similar to the iris in a camera lense) was as effective. More important was Bovy's finding that a static "close up" of each detail cultivated cue attending more effectively than either irising or zooming. It may be that the necessary feature of cue attending methods is the successive isolation of cues by any means available. If this is found to be the case with computer attributes as is expected, one might expect that computer research will not add appreciably to prescriptive design theories.

Computers in Instructional Design Theory

One could imagine a level of prescriptive theory that is even closer to practice and more inclusive than instructional propositions. Here we would need to include most of the considerations of the instructional designer including the ways that various constraints on cost, delivery, and format (among others) are accomodated in the specific design of an plan to develop, deliver and evaluate instruction in a specific setting. Here computers and other media must be considered as devices that code, deliver, record, store and transform instructional presentations. The outcome of interest in design and development is usually some cost, appeal or efficiency goal however, and so computers again enter the mix of constructs as a potentially important factor. Note, however that the descriptive theories that control these decisions derive from economics,

information theory or clinical psychology -- not from learning or instructional theory.

Summary and Conclusions

Research on the instructional uses of computers runs the risk of repeating the historically consistent errors of research on other media. To date, there is clear evidence that studies which have demonstrated that computers (or other media) are instrumental in learning have been subject to compelling rival hypotheses. Upon examination it seems that increases in learning from CBI can be shown to be due to the uncontrolled effects of content, instructional method or novelty.

More theoretically directed research on computers, called "media attribute" theory (e.g. Salomon, 1979), also has it's limitation. While it provides adequate descriptive propositions for instructional theories, it can be shown to be focused on "sufficient" conditions that are, at best, difficult to translate for prescriptive theories. When goal-directed prescriptive theory is sought, propositions must be based on an understanding of the "necessary" or criterial features of instructional methods. While necessary features are contained in all successful CBI presentations, they are not usually specified or discoverable from typical reports of research.

The use of computers becomes crucial in the set of considerations that exist at the development and implementation stages of instruction. Here the concern is with selecting a delivery vehicle that will accomodate available resources and constraints on the distribution of the instructional program to students in different locations. Under specific conditions computers will be found to be the preferred delivery vehicle for instructional programs.

This paper recommends that we deemphasize research that compares computers with other media of instruction and that we exercise caution with "media attribute" research since the latter does not translate to prescriptive theories. Instead we should focus on research that identifies the necessary features of methods that enhance learning. This area of research has the potential to contribute to both descriptive and prescriptive instructional theory.

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Abstract

This document summarizes reviews of computer assisted Instruction research and recent meta-analytical reports. It suggests that all research on the learning benefits of the instructional uses of computers be halted since all existing evidence indicates that computers do not yield learning benefits. Evidence to the contrary is shown to be subject to compelling rival hypotheses concerning novelty effects and instructional method/ content effects on learning. Recent "symbol system" theories are reviewed and it is concluded that existing evidence suggests that while cognitive skills can be cultivated with computer related symbol systems, the effects are available from other mediums. So, it is concluded that computers are useful in delivering instruction and they may influence the cost or distribution equity of instruction. However, they should not be expected to contribute any unique effects to learning that is not allready available from other delivery devices.